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A BRIEF STUDY OF SOFT SOLDERING Including a Review of some recent Researches

by

L. G. EARLE, B.Sc., A.R.S.M.

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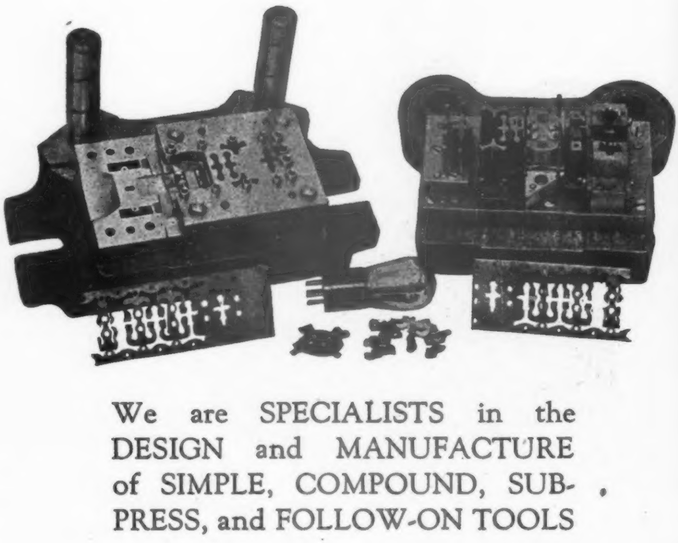

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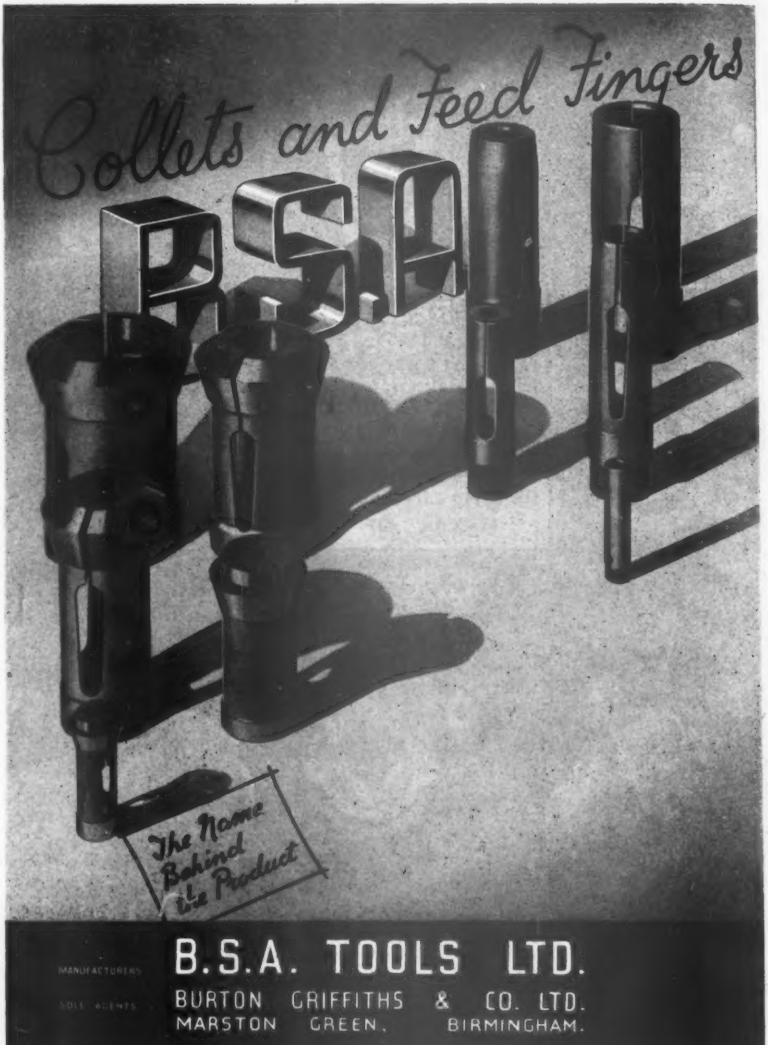
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A BRIEF STUDY OF SOFT SOLDERING
including a Review of some Recent Researches.

By L. G. EARLE, B.Sc., A.R.S.M.
(Messrs. Capper Pass & Son, Ltd., Bristol.)

It is probably true to say that most users of soft solders for jointing purposes are concerned with two main aspects of the matter:

(1) Is the solder easy to use? If so, it must melt without any undue amount of heat; it must wet the basis metal and flow smoothly, penetrating quickly and deeply.

(2) Is the resulting joint sound and free from cracks and porosity, and strong enough to resist the rough usage which it is likely to receive in service?

Until recently, soft-soldering has often been a somewhat haphazard proceeding, and indeed in some factories still is. But, like any other production process, its principles can be studied and a sound technology evolved.

The purpose of this paper is to enquire into some of the factors which affect joint formation and the soundness of joints; and to present the results of some recent researches which may enable soldering operations to be planned with the same probability of success as other methods of jointing; before actually putting the work out into the factory.

Before going on to these aspects of the matter, however, it is necessary that something should be said for the benefit of those without expert metallurgical knowledge, upon the constitution of tin-lead solders from which the more complex solders are developed.

ON THE CONSTITUTION OF TIN-LEAD SOLDERS.

Most solder users will be familiar with the equilibrium diagram reproduced in **Fig. 1**, having seen it many times before.

The heavy lines AB and BC show the melting points of alloys of tin and lead in all proportions. Addition of tin to lead or lead to tin results in an alloy of lower melting point than either of the primary constituents. The lowest melting point alloy of the whole group is one containing 63% tin and 37% lead which melts at 183°C., compared with 327°C. for pure lead and 232°C. for pure tin. This alloy is known as the eutectic and its significance is that in this alloy, and in this alloy alone, the tin and lead crystallize together at the same temperature. To appreciate the full meaning

of this phrase, consider an alloy containing only 32% tin (B.S. Grade L). Above 253°C. it is completely molten and homogeneous, but when cooled below 253°C. (Called the " liquidus " temperature) particles of lead begin to crystallize out ; at first only a few, but gradually building up until the alloy reaches the consistency of a mush around say 200°C. This increase in the number and size of the lead particles continues until a temperature of 183°C. (the solidus) is reached, at which temperature the balance of the alloy, now containing 63% of tin, gradually solidifies. Reproduced in **Fig. 3** is a photomicrograph of such an alloy and, if the black particles be considered as solid lead crystals suspended in liquid metal of eutectic composition, then a true visual picture will emerge of the alloy as it exists at a temperature a shade above the solidus. This is the traditional composition of tin-lead solder used for cable wiping, chosen because an alloy consisting of roughly three parts lead to two parts eutectic is just right to work a smooth joint.

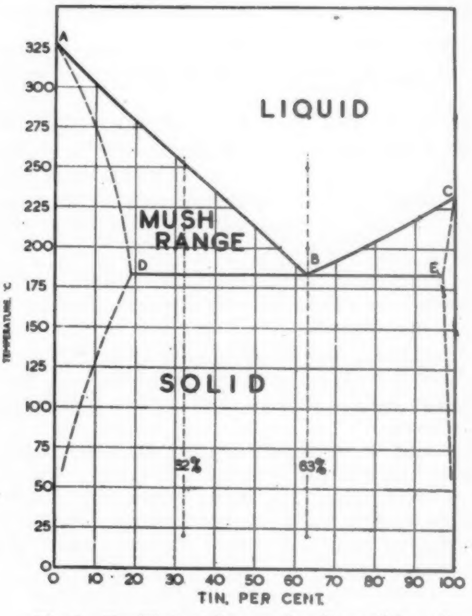

Fig. 1. Equilibrium diagram for alloys of tin and lead in all proportions.

Compare this with the eutectic solder itself (midway between B.S. Grades A and K, widely used by the radio, electrical and instrument manufacturing industries). At 250°C. the solder is molten. At 200°C., when a 32% tin solder is a mush, it is still molten, and it does not begin to solidify until the temperature of 183°C. is reached. In this respect, therefore, a eutectic solder is like a pure metal, for its solidus and liquidus temperatures coincide. The structure of the tin-lead eutectic is illustrated in **Fig. 2.** It is

lamallar in character and the absence of primary crystals of either metal will be noted. Eutectic alloys are sometimes called "sharp-melting" alloys because they melt at a single temperature, and this has, on occasion, given rise to misunderstanding. It should be appreciated that even a eutectic alloy takes a tangible time to solidify and does not simply freeze in a flash when it reaches a

Fig. 2. Photomicrograph of 63% tin, 37% lead eutectic alloy × 70.

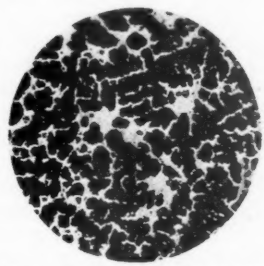

Fig. 3. Photomicrograph of 32% tin, 68% lead alloy × 34.

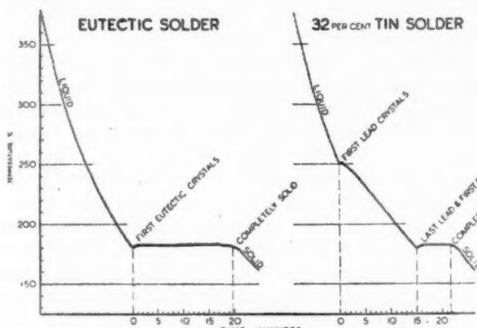

Fig. 4. Comparative cooling curves of 32% tin and tin-lead eutectic alloys.

certain critioal temperature. This is demonstrated by the two curves reproduced in **Fig. 4**, in which the temperature of the 63% tin eutectic alloy was first taken at ½-minute intervals as it cooled down from 360° to 160°C., and the procedure was then repeated under identical conditions for a 32% tin alloy. These "cooling curves," as they are called, are valuable in determining the various stages of solidification of an alloy. When any constituent starts to separate out some of its latent heat of fusion is released,

and this causes an arrest in the otherwise steady rate of cooling of the alloy. If the constituent crystallizes completely at constant temperature (as is the case with a eutectic or pure metal) the time during which solidification proceeds is indicated by a flat on the curve. In a two-component alloy, however, such as a 32 per cent. tin alloy, the lead comes out over a range of temperature, and the effect is to reduce the slope of the curve. When the alloy is completely solid the original slope is resumed, and the duration of solidification may be read off against the time base.

Referring once more to Fig. 1, there are areas at either end of the diagram bounded by the dotted lines AD and CE which represent the limits of "solid solution". Diagrams such as this are reproduced in innumerable textbooks and it should be stressed that they are based upon the most careful observations and painstaking work. The parts shown in dotted lines, may, nevertheless, be misleading to practical engineers and metallurgists because, in point of fact, equilibrium conditions never obtain in practice. The legitimate inference to be drawn from diagrams such as Fig. 1 is that alloys containing 19 per cent. or less of tin contain no eutectic. Cooled under conditions such as obtain in practice, however, tin-lead alloys contain a trace of eutectic even as low as 7½ per cent. tin content, and no alloy containing 7½ per cent. tin or more will be completely solid above 183°C.

From the earlier comparison between solders of 32% and 63% tin content it will be apparent that the characteristics and properties of any particular alloy will depend upon (1) the relative proportions of lead and eutectic in the alloy, and (2) the characteristics and properties of the particular eutectic which it contains; for additional metals such as silver and antimony go into the eutectic part of the alloy and the lead particles remain substantially pure lead.

It is widely known that the tin-antimony-lead eutectic contains only 55·5% tin (compared with 63% for the antimony-free tin-lead eutectic), whence it follows that if a 32% tin (antimony-free) alloy produces a certain desirable degree of mush for cable wiping, a similar degree of mush will obtain in an antimonial alloy containing only 29% of tin; with a saving of 3 units per cent. of the more valuable constituent of the alloy.

Three-quarters of a century ago, the firm with which the author is associated introduced the antimonial range of solders to economize tin; and these solders have been very widely used since then. Recently in 1942, when the utmost economy became not merely a matter of cost to the consumer but one of prime national urgency, even greater attention was naturally directed toward solder of this type. The firm also put in hand researches to study the possibilities of using silver as well as antimony partly to replace tin in soft solders.

Since the eutectic is the key to any solder alloy group, the tin-

lead-silver and tin-lead-antimony-silver eutectics had first to be isolated. This was done, and we have now at our disposal four tin-rich eutectics upon any one of which a complete range of soft solders of varying tin content may be based. Each group has its own peculiar characteristics, and an attempt is made in this paper to indicate the best use which production engineers may make of the alloys thus made available.

In Table I below the compositions and melting points of the four eutectics are set out. For convenience, the four groups will hereafter be referred to by the letters "B" (binary tin-lead), "T" (ternary tin-lead-silver), "Q" (quaternary tin-lead-antimony-silver) and "P" (tin-lead-antimony).

TABLE I

	"B" Eutectic	"P" Eutectic	"T" Eutectic	"Q" Eutectic
Tin, per cent.	63	55·5	62·5	54·8
Antimony, per cent. ...	nil	3·4	nil	3·3
Silver, per cent. ...	nil	nil	1·35	1·2
Lead	bal.	bal.	bal.	bal.
Melting point, °C. ...	183	185	178	181

These four tin-bearing eutectics may each be mixed with lead in different proportions and give rise to four parallel solder groups, any one of which contains solders of a grade suitable for every normal soldering duty: thus presenting an overwhelmingly wide choice to the embarrassed user.

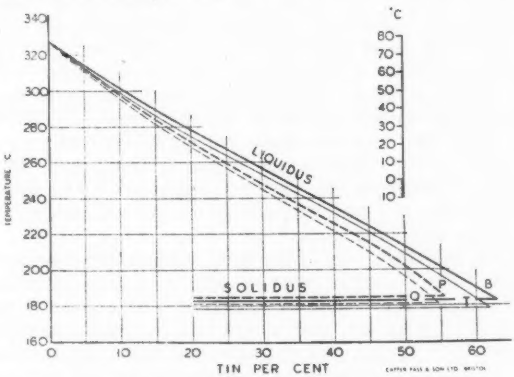

Fig. 5. Graph showing the melting point (liquidus) and freezing point (solidus) for all tin-rich solders in the usual working range of composition.

It will be noted that the antimony content of the " P " and " Q " eutectics is approximately 6% of the tin content ; and the silver in " T " and " Q " roughly 2·2% of the tin. Addition of antimony or silver in excess of these proportions results in the formation of tin-antimony and tin-silver compounds respectively.

Fig. 5 shows the difference in the position of the " melting " (liquidus) and " freezing " (solidus) points for solders formed by mixing lead with each of these four eutectics. Antimony lowers the liquidus and raises the solidus for any given tin content, whilst silver uniformly lowers both solidus and liquidus.

JOINT FORMATION.

If attention is now turned from consideration of the constitution of soft solders to the soldering process itself, two propositions of fundamental importance may be stated.

(1) That no matter how the process of soldering is carried out, no solder flow or penetration of a joint can take place until the molten solder has wetted the basis metal.

(2) That as well as the solder itself, the flux, the character of the basis metal, its surface condition, thermal conductivity, specific heat and thickness, all have a bearing upon the soldering operation.

It is not possible, therefore, to measure the soldering characteristics of a solder independently, but only to compare " soldering-systems " embracing solder, flux and the basis metal.

It is the author's experience that when the man on the bench says soldering is " easy " he means that the molten solder has quickly wetted the basis metal and thereafter flowed smoothly over the surface and penetrated the joint without his having to apply an undue amount of heat. Conversely, soldering is said to be " difficult " when the operator has to take excessive time and apply much heat to get the solder to wet the stock and flow freely. In the absence of better data the user has been compelled hitherto to use the melting point of the solder as an " ease of soldering " index, but most practical men have met with conditions when the solder melts but does not wet, and melting point alone, as will be shown, is not by any means the whole story.

It follows, therefore, that if the time/temperature-wetting characteristics of different solder systems can be exactly measured, our ability to forecast the " ease of soldering " of a given " soldering set-up " will be achieved, and this phrase should be understood to embrace not only solder, flux and basis metal but the application of heat to the system and the thermal environment (i.e., conditions of preheat, lagging, chill, etc.) of the system. To this end an apparatus called the kollagraph has been developed. It is fully described in a

paper recently published by the Institute of Metals (Ref. : Journal Institute of Metals, Vol. 71, Feb., 1945) ; the point of practical importance to solder users being that, by means of this instrument, the lowest temperature at which the molten solder instantaneously wets the basis metal can be exactly measured. This critical temperature is known by the initials M.E.W.T. (Minimum Effective Wetting Temperature) and the M.E.W.T. may be taken as an index of the amount of heat which has to be applied to a solder system to obtain instantaneous wetting. Once wetting is achieved, solder flow must follow. The M.E.W.T. is thus a yardstick relating to wetting, in terms of which the effect of any variation in a soldering set-up may be expressed.

In **Figs. 6** and **7** M.E.W.T. values are plotted against tin content for each of the four main solder groups, in conjunction with six different basis metals. In all cases the thickness of the basis metal was 0·012 in. and zinc ammonium chloride (D.T.D. 81) flux was used.

Effect of Tin Content of the Solder.

Approaching the eutectic composition lowers the M.E.W.T., but the relationship varies a good deal with solder composition and the basis metal. Solders are shown to be selective in their reaction to different basis metals.

Effect of Basis Metal.

In all cases copper has a higher M.E.W.T. than tinplate, which means that more heat has to be applied to produce instantaneous wetting of a given solder on copper of a certain thickness, than on tinplate of like thickness. The following table shows the amount quantitatively, in terms of solder temperature, for basis metal 0·012 in. thick.

TABLE II

Group letter	Tin %	M.E.W.T., °C.			Tin %	M.E.W.T., °C.		
		Copper	Tin-plate	Diff.		Copper	Tin-plate	Diff.
B	63	279	239	40	20	416	313	103
T	62	276	230	46	20	412	315	97
P	55·5	314	238	76	20	397	316	71
Q	54·8	305	237	68	20	402	301	101

Flux, zinc ammonium chloride in all cases.

Comparison may also be made by taking 50 : 50 tin-lead solder (which has a M.E.W.T. of 252°C. on tinplate with zinc ammonium

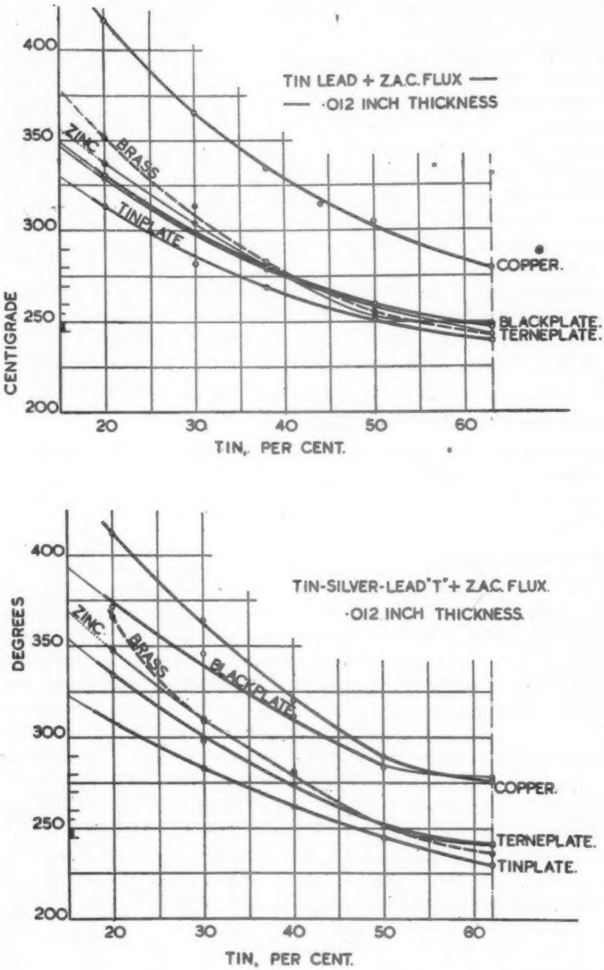

Fig. 6.

Graphs showing the minimum effecting wetting temperatures for solders of different compositions on the six most common basis metals, each ·012 in. thick with D.T.D. 81 flux.

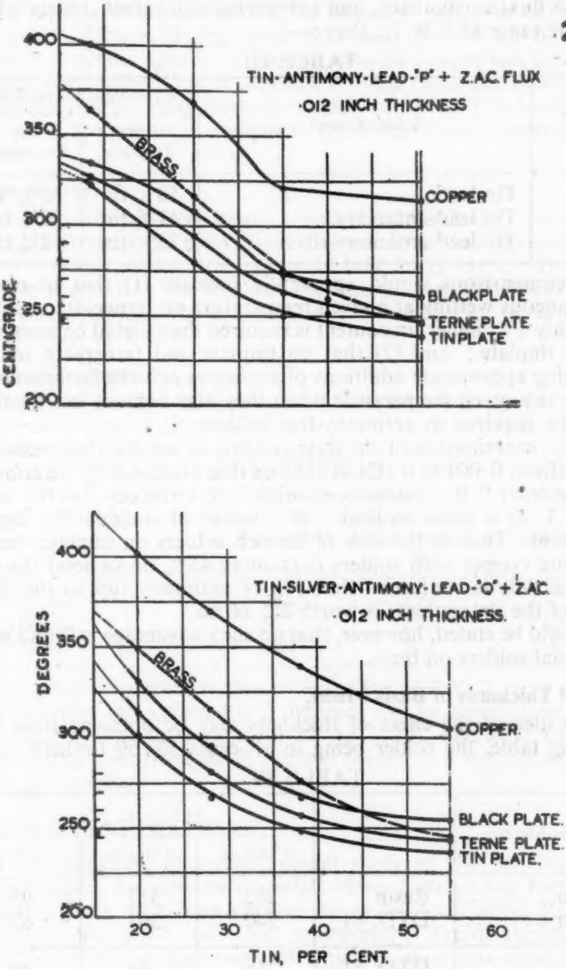

Fig. 7.

Graphs showing the minimum effecting wetting temperatures for solders of different compositions on the six most common basis metals, each ·012 in. thick with D.T.D. 81 flux.

chloride flux) as standard, and comparing equivalent solders which have the same M.E.W.T., thus :—

TABLE III

Group letter	Solder Group	Equivalent tin content	
		on Tinplate	on Terneplate
B	Tin-lead	50% tin	55% tin
P	Tin-lead-antimony	41% tin	50% tin
Q	Tin-lead-antimony-silver ...	35% tin	42% tin

These comparisons would apparently indicate (1) that to obtain instantaneous wetting at a given temperature on terneplate, a solder of roughly 5% higher tin content is required than would be appropriate for tinplate ; and (2) that on tinplate and terneplate solders containing appropriate additions of antimony achieve instantaneous wetting at a given temperature when they also contain less tin than would be required in antimony-free solders.

Similar examination of the data relating to several thicknesses of copper (from 0·004 to 0·021 in.) shows that around 40% tin content an antimonial " P " solder containing 2½% antimony has the same M.E.W.T. as a plain tin-lead " B " solder of roughly 5% higher tin content. Thus in the case of tin-rich solders on tinplate, terneplate (and copper with solders containing 45% tin or less) the old empirical rule is confirmed that 1% of antimony (up to the limit of 6% of the tin content) is worth 2% of tin.

It should be stated, however, that no such advantage is found with antimonial solders on brass.

Effect of Thickness of Basis Metal.

Some idea of the effect of thickness may be obtained from the following table, the solder being in all cases 50 : 50 tin-lead.

TABLE IV

Basis Metal	Flux	M.E.W.T., °C.		
		0·004 in.	0·012 in.	Diff.
Copper ...	Resin	262	357	95
Copper	DTD. 81	240	303	63
Zinc	DTD. 81	218	244	26
Brass	DTD. 81	214	250	36
Tinplate ...	DTD. 81	217	252	35

D.T.D. 81 is the Air Ministry specification covering flux of the zinc ammonium chloride type.

It is noticeable that increasing the thickness when the basis metal is copper affects soldering more drastically than when it is zinc, brass or tinplate. This is, no doubt, because copper has the higher thermal conductivity. Any conditions which cause the transfer and dispersion of heat away from the molten solder tend to increase the minimum temperature necessary to bring about instantaneous wetting.

Effect of Flux.

Comparison between items 1 and 2 in Table IV shows that changing from plain resin flux to zinc-ammonium chloride, with 50 : 50 tin-lead solder, lowers the M.E.W.T. 22°-54°C. The effect is more marked on the thicker basis metal. Certain "activated" resin fluxes, though, have a M.E.W.T. within 10°C. or so of that with D.T.D. 81 flux.

Effect of Preheat.

The tests detailed in Table V were made with 50 : 50 tin-lead solder on copper with resin flux.

TABLE V

Thickness	M.E.W.T., °C.		
	No Preheat	Preheated to 120°C.	Difference
0·004 in.	262	210	52
0·012 in.	357	252	105
0·021 in.	400	302	98

The effect of preheat is thus to lower the M.E.W.T.

It may also be expressed in a different way by saying that, in this case, preheating the work from 20° to 120°C. had a similar effect to changing over from 40/60 tin-lead solder to a eutectic solder of 63% tin content.

SOLDER PENETRATION.

A mathematical and experimental study of the penetration of molten solder between two parallel plane surfaces has been made by Latin (Refs. Brit. Non-Ferrous Research Association, Report to Members No. RRA. 647 (inc. references); Trans. Faraday Soc. 1938, 34, 1384), in the course of which work it was shown that if the two surfaces between which molten solder is advancing are maintained at a substantial superheat above the liquidus of the solder the penetration rate varies almost exactly with the spacing. It was also found that whilst the penetration of all solders into spaces from 0·0015 in. width to 0·020 in. was good, only solders

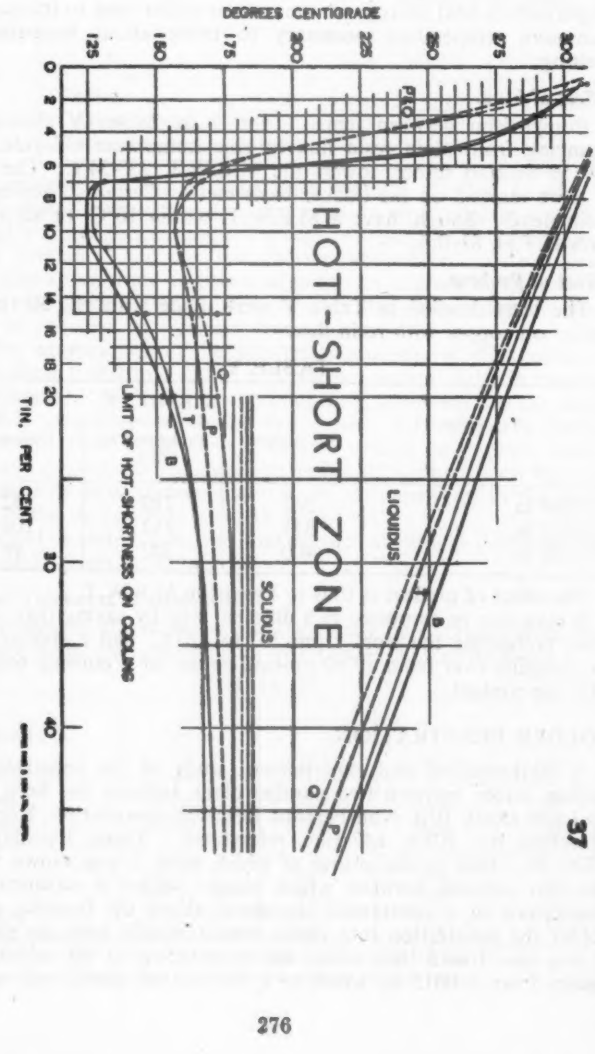

Fig. 15. Graph showing the limit of hot-shortness in solders over a wide range of composition.

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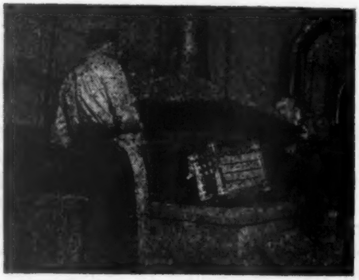
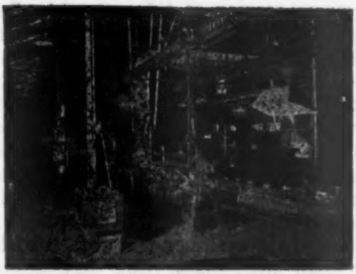


Close-up view of aircraft radiator matrix being drained after soldering by complete immersion.

By courtesy of Serck Radiators, Ltd.



General view of soldering machine for high speed side-seaming can bodies at a rate of 300 cans per minute.

By courtesy of The Metal Box Co., Ltd.

General view of soldering muchine for the production of four-gallon petrol cans.

By courtesy of the War Department and National Oil Refineries, Ltd.

of the eutectic or near-eutectic composition are wholly satisfactory as regards penetration into spaces 0·001 and 0·0015 in. wide.

It can be shown mathematically that the rate of advance of molten solder as it penetrates a joint is directly proportional to the interfacial tension between the fluxed basis metal and the flux-covered molten solder : proportional, that is to say, to the force of attraction drawing the solder into the joint. It is also inversely proportional to the combined viscosity of molten solder and flux. If the solder is fully molten, and the flux reasonably fluid, this impedance to free flow is small and may be ignored, and the rate of penetration will vary with the resultant interfacial tension between solder and stock.

The kollagraph referred to above is capable of determining the interfacial tension of different solder-flux-stock systems. In general terms there is no great difference btween any of the tin-rich solders with and without antimony or silver ; with active or inactive flux ; on copper, brass, zinc, tinplate, terne or blackplate. The difference in the practical behaviour of these different solder systems arises primarily from their different wetting characteristics rather than from any major difference in the forces of attraction once the basis stock is wetted. Most of the combinations indicated above result in an interfacial tension between 280 and 340 dynes/cm. As would be expected, the interfacial tension is higher when the basis metal is tin-coated than when it is not. It is also higher with an "active" flux than with plain resin flux, though the addition of certain "activating agents" to resin flux raises the inter-facial tension between the molten solder and the fluxed basis stock.,

The lowest values were obtained with an alloy containing 4% of antimony and 5% of tin, balance lead, with only 215 dynes/cm. ; whilst the low tin lead-silver solders have a surface tension between 250 and 290 dynes/cm. on copper with DTD. 81 flux.

In these circumstances it is only to be expected that the rate of penetration shows little variation with different tin-rich solders. In a copper joint spaced 0·0035 in. with zinc ammonium chloride flux, the uniform rate of advance of the solder, so long as it remains above the liquidus, is about an inch a second. The depth of penetration is, however, another matter.

In all forms of soldering, other than by complete immersion, the set-up is characterized by a source of heat at the entry end of the joint : generally a pool of molten solder kept hot by a soldering bolt or a gas jet, whilst the other end of the joint is generally at room temperature. The molten solder has thus to advance along a falling temperature gradient, and the depth of its penetration is limited by the temperature gradient in the joint. This conclusion is of the utmost importance if the factors controlling the penetration of solder into a normal joint are to be appreciated in their proper relationship. No matter what the force of interfacial tension, the relative vis-

cosities of solder and flux or the spacing of the joint, the solder cannot bond with the basis metal beyond a certain point. The point where its advancing front is cooled below the temperature at which it is capable of wetting the sides of the joint.

The results of six series of penetration tests are plotted in Fig. 8. Test pieces of copper, steel and tinplate 0·012 in. thick ; brass, 0·011 in. thick ; and zinc 0·010 in. thick, were clamped together with nichrome separating strips between to give the required joint spacing. The assemblies were end-dipped into a bath of molten solder, the strips being in all cases fluxed with zinc ammonium chloride.

Table VI provides a key to the different variables which were explored.

TABLE VI

Test Series	A	B	C
Joint spacing	·010 in.	·010 in.	·010 in.
Tin content of solder ...	50%	50%	20%
Temp. of metal strip ...	100°C.	20°C.	20°C.
Duration of test ...	30 secs.	30 secs.	30 secs.
Test Series	**D**	**E**	**F**
Joint spacing	·003 in.	·003 in.	·010 in.
Tin content of solder ...	50%	50%	50%
Temp. of metal strip ...	100°C.	20°C.	20°C.
Duration of test ...	30 secs.	30 secs.	5 secs.

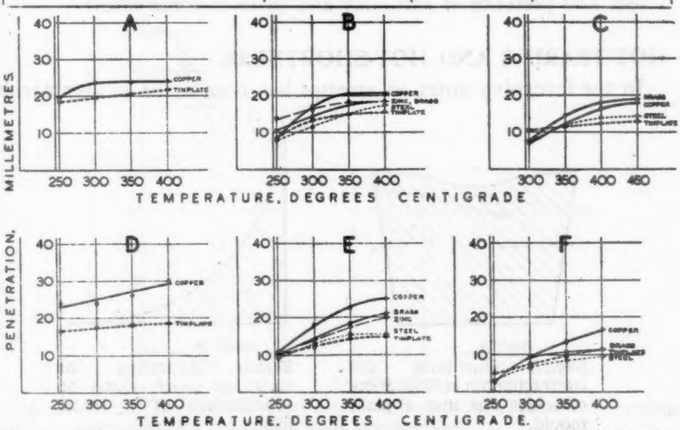


Fig. 8. Effect of various factors upon the depth of penetration. See Table VI.

The whole matter is exceediingly complicated and any attempted analysis of the factors which effect depth of penetration can only be dealt with in a relatively superficial manner in this paper. It may, however, be deduced from the results summarized in **Fig. 8** that :—

(1) The depth of penetration, under identical thermal conditions, with a 20% tin solder is somewhat, though not greatly, less than with a 50% tin solder (c.f. Series " B " and " C ").

(2) The depth of penetration is somewhat, though not much greater with narrow than with wide spacing (c.f. Series " B " and " E ").

(3) High solder temperature, particularly at narrow spacing, favours penetration.

(4) Higher thermal conductivity of the stock, particularly at narrow spacing, favours penetration.

(5) Preheating the stock favours penetration (c.f. Series " A " with " B " and " D " with " E ").

(6) Longer time in contact with the heating medium favours penetration (c.f. Series " B " and " F ").

To summarize, it is the author's view that depth of penetration will be increased, first, by any device which has the effect of advancing the point at which the solder ceases to wet the basis metal (e.g., high soldering temperature, long time of contact with the heat source, high thermal conductivity of basis metal, preheat, lagging) ; and second, by those factors which lower the minimum temperature at which the solder can wet the basis metal (e.g. high tin content of solder and presence of antimony and silver in some cases).

HOT-TEARING AND HOT-SHORTNESS.

In the foregoing notes an attempt has been made to summarize

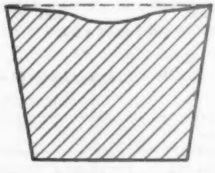


FIGURE 9

Sketch illustrating the contraction on solidification of solder cast into a plain mould.

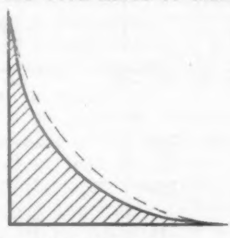


FIGURE 10

Sketch illustrating the shrinkage which occurs on solidification of a solder fillet.

some of the relevant factors which govern the formation of a solder joint. What happens when subsequently the solder cools ? As the last of the molten solder solidifies at the eutectic temperature it undergoes a volume contraction. If molten solder is poured into a chill mould the contraction takes the form illustrated in Fig. 9 and it is believed, though not proven, that a solder fillet contracts on solidification in the manner sketched in Fig. 10 and no rupture takes place. When the metal is quite solid, however, on further cooling from a temperature immediately below the solidus down to room temperature, it undergoes a further contraction which sometimes causes transverse hair-line cracks in lead-rich solders. In order to throw some light upon this phenomenon the chill die sketched in Fig. 11 (but having a plain top half without the pin " A " or web

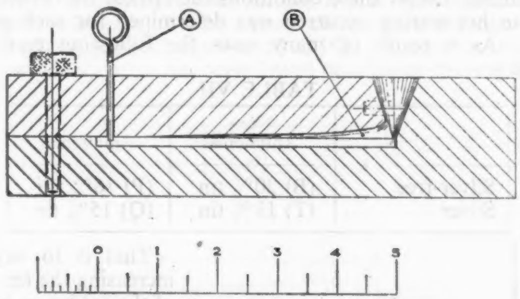


Fig. 11. Die for solder contraction tests.

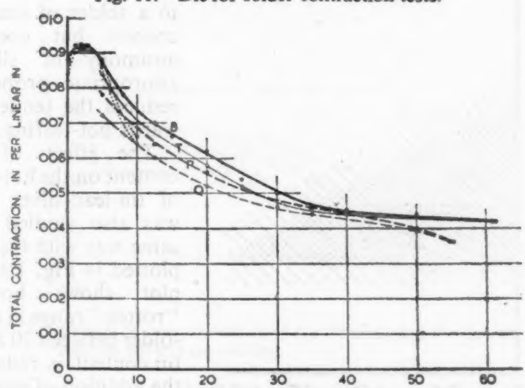


Fig. 12. Graph showing the linear contraction upon solidification and cooling of solder test pieces of varying compositions.

" B ") was constructed: and solders covering a wide range of composition were cast into it. The die had an exact length of 5.000 in. at room temperature. The mean linear contractions of triplicate tests are plotted in **Fig. 12,** the nomenclature mentioned on page 269 being followed. These tests reveal the effect of solder composition on total contraction; but resistance to cracking or hot-tearing is a combined function of the linear contraction of the solder and its tenacity at elevated temperatures.

Accordingly, another set of tests was carried out, using the actual die illustrated, so that the specimens were firmly held at both ends. Under certain conditions hot-tearing resulted. The superheat of the solder was standardized at 100°C. above its liquidus and the mould temperature was held around 35°C., the tin content of the solder being varied. Under these conditions the critical tin content above which no hot-tearing occurred was determined for each group of solders. As a result of many tests the following equivalences emerged :—

TABLE VII

	Non-Antimonial	Antimonial
Silver-free	(B) 20% tin	(P) 16% tin
Silver	(T) 19% tin	(Q) 15% tin

That is to say either increasing the tin content of the solder, or changing to a solder of similar tin content but containing antimony or silver in appropriate proportions, reduces the tendency towards hot-tearing.

The effect of silver content on the hot-tearing of tin-lead-silver solders was also studied in the same way with the results plotted in **Fig. 13.** This plot shows how the "rotten" range in tin-lead solder between 20 and 5% tin content is reduced by the addition of silver.

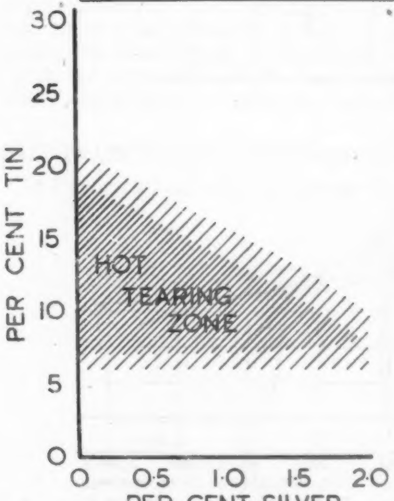


Fig. 13. Results of hot-tearing tests on lead-tin-silver solders.

Stress induced by the contraction of the solder on cooling is one form of

potential joint weakness in lead-rich solders ; but another arises from the imposition of external stress, as for example by handling and mechanical movement before the solder is sufficiently set to withstand such shocks. This was a common cause of leaks in radiators before the vital importance of good jigging was fully realized, and is the cause of occasional weak-laps in open-topped cans, as well as of a great deal more potential trouble in solder joints of all types. Reference to Fig. 1 would suggest that so long as the joint is protected from shocks in the mush range no trouble would result. This inference is correct but it has only recently been observed that lead-rich solders are hot-short well below the eutectic temperature.

To investigate this matter further, use has been made of a simple but effective apparatus devised by the British Non-Ferrous Metals Research Association, to whom the author wishes to make acknowledgment. This apparatus, sketched in **Fig. 14,** consists simply of a hinged mould ; and it has been found possible to determine with a

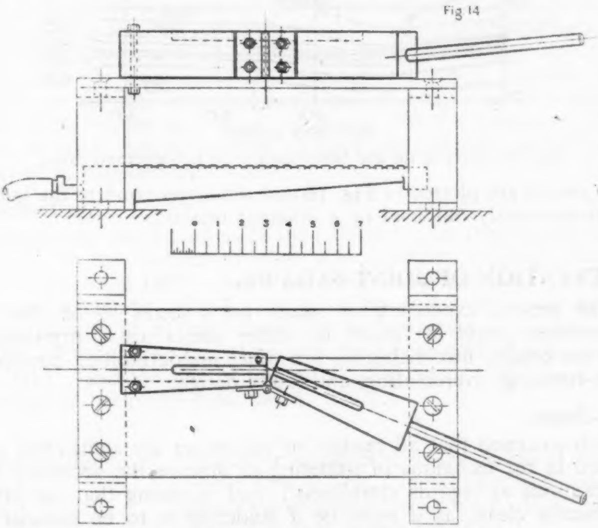


Fig. 14. **Sketch of open mould used for determining the hot-shortness limit of solders on cooling.**

fair degree of precision the limit of hot-shortness over a wide range of composition. The results are plotted in **Fig. 15**. The lower group of curves indicates the limit of hot-shortness below which the solder

withstood bending without cracking, whilst between this lower limit and the liquidus the solder cracked when bent. As in the case of linear contraction and hot-tearing, it is found that the hot-shortness range is reduced with rising tin content, reaching a minimum at the eutectic composition. It is also slightly reduced by addition of silver and considerably by addition of antimony in appropriate proportions. For any given tin content the least hot-shortness range is found in tin-lead-antimony-silver " Q " solders.

The method has been extended to studying the effect of silver in reducing the tendency of lead-rich solders towards hot-shortness.

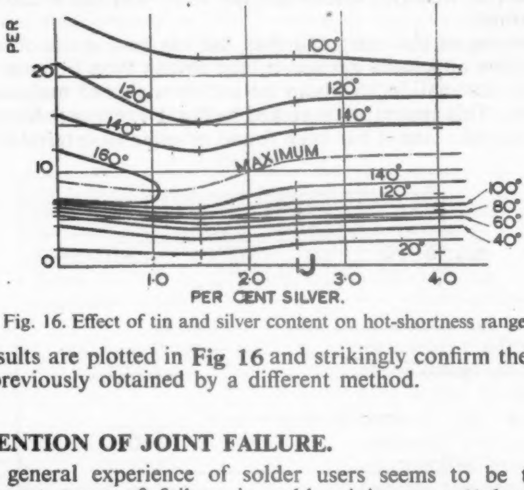


Fig. 16. Effect of tin and silver content on hot-shortness range.

The results are plotted in Fig 16 and strikingly confirm the indications previously obtained by a different method.

PREVENTION OF JOINT FAILURE.

The general experience of solder users seems to be that the commonest cause of failure in solder joints are "dry-joints," hairline cracks, flux inclusions are other discontinuities, accidental over-stressing, over-heating, and faulty design.

Dry-Joints.

It is assumed that all readers of this paper are sufficiently well versed in the technique of soldering to observe the necessary first precautions as regards cleanliness ; and assuming that the job is absolutely clean, as it must be if soldering is to be successfully carried out, " dry-joints " can only result if an attempt is made to carry out the soldering operation at a temperature below the minimum wetting temperature for the particular conditions obtaining. The most obvious course, namely, to raise the soldering temperature, is not always practicable ; and it may be necessary to lower the wetting temperature instead. The time-honoured way was

by increasing the tin content of the solder, but equivalent results may sometimes be obtained by adding antimony or silver in appropriate proportions ; or by using basis metal of less thickness ; or, if this is impracticable, by preheating, which reduces its "apparent thickness" ; or by precoating the basis metal with tin or with lead alloy ; or by using a more active flux. There are a variety of ways of lowering the minimum wetting temperature of a system, and the relative effectiveness of these various means is briefly discussed on pages 271 — 275.

Hairline Cracks.

It is possible to reduce the tendency towards hot-tearing or hot shortness of any antimony-free solder, without raising its tin content, by making appropriate addition of antimony. Silver, in suitable proportions, is also beneficial, though less so than antimony.

Over-stressing and Faulty Design.

A stressed solder joint should always be mechanically locked, and it should be remembered that a plain lap joint abruptly loaded in tension at normal temperatures breaks around 4,000-5,000 lbs/sq. in. and, when subjected to sustained creep, breaks at roughly one-fifth to one-quarter of this stress. The tearing strength of a solder joint when one member is being slowly peeled away from the other is only 30-50 lbs. per inch length of joint ; which is fortunate, otherwise, it would not be possible to open the ordinary sardine pack, even when supplied with a key.

Overheating.

Any solder containing more than about 8% tin (the exact content varies with the amount of silver and antimony present) collapses abruptly around 180°C. due to the presence of low melting eutectic. Alloys containing only 1 or 2% of tin and 1½% silver have a potential sphere of usefulness up to temperatures approaching 300°C., although, so far, creep tests have been carried only as high as 200°C., and the rate of falling off of strength with temperature has not yet been fully determined.

Acknowledgement. The author is indebted to the Board of Messrs. Capper Pass & Son, Limited, for permission to publish the results of certain work which appears for the first time in this paper.

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INSTITUTION NOTES

October, 1945

October Meetings.

1st Coventry Graduate Section. A lecture will be given by R. L. Lloyd, Grad. I.P.E., on "Modern Practice in Multi-Spindle Automatic Design," at the Technical College, Coventry, Room A5, at 6-45 p.m.

1st Yorkshire Section. A lecture will be given by J. Loxham, M.I.P.E., M.I.Mech.E., F.R.S.A., on "The Inspection and Preparation of Straight Edges and Flat Surfaces," at the Hotel Metropole, Leeds, at 7-00 p.m.

5th Lincoln Sub-Section. Open Discussion on "Unification of Screw Threads." E. Burgess, M.I.P.E. at Lincoln Technical College, at 6-30 p.m.

8th Manchester Graduate Section. A lecture will be given by Dr. D. Binnie, on "Steel Making and Rolling," at the College of Technology, Manchester, at 7-15 p.m.

9th North-Eastern Graduate Section. A lecture will be given by R. D. Williams, Grad. I.P.E., on "The Construction of Machine Tools," at the Neville Hall Mining Institution, Newcastle-on-Tyne, at 6-30 p.m.

9th Luton and District Section. Film show at The Small Assembly Room, Town Hall, Luton, at 7-00 p.m.

11th South Wales and Monmouthshire Section. A lecture will be given by A. H. Huckle, F.I.F.M., M.I.Ec.E., A.M.I.I.A., on "Production Planning and Control," at the South Wales Institute of Engineers, Park Place, Cardiff, at 6-30 p.m.

11th Leicester Section. A lecture will be given by Dr. W. Wilson on "Electronics in the Service of the Engineer," at the Leicester College of Technology, at 7-00 p.m.

11th London Section. A lecture will be given by C. A. Gladman, B.Sc., A.M.I.P.E. on "Engineering Drawings in Relation to Production and Inspection," at the Institution of Mechanical Engineers, Lecture Hall, Storey's Gate, St. James' Park, S.W.1, at 6-30 p.m.

15th Derby Sub-Section. A lecture will be given by Prof. H.W. Swift of Sheffield University on "Deep Drawing of Sheet Metals," at the School of Art, Green Lane, Derby, at 6-30 p.m.

15th Halifax Section. A lecture will be given by J. Loxham, M.I.P.E., M.I.Mech.E., F.R.S.A., on "Measurement of Straight Edges, Flat Surfaces, etc.," at the Technical College, Halifax, at 7-00 p.m.

October Meetings.—*cont.*

17th Manchester Section. A lecture will be given by A. G. Doughty, Esq., on " Use of Disabled Personnel in Industry," at the College of Technology, Manchester, at 7-15 p.m.

17th Sheffield Section. A lecture will be given by F. Pickworth, Esq., on " Development Problems of Sheffield Steel Plants," at The Royal Victoria Station Hotel, Sheffield, at 6-30 p.m.

17th Preston Section. A lecture will be given by T. C. Parker, Esq., on " Cold Forging and Thread Rolling of Bolts and Screws," at the Harris Institute, Corporation St., Preston, at 7-15 p.m.

17th Birmingham Section. A discussion on " Unification of Screw Threads." S. J. Harley, B.Sc., M.I.P.E., will preside at the James Watt Memorial Hall, at 7-00 p.m.

18th Glasgow Section. A lecture will be given by A. Chalmers, B.Sc., H.M. Inspector of Factories, on " Accident Prevention," at the Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, C.2, at 7-15 p.m.

18th Wolverhampton Section. A lecture will be given by H. E. Hows, M.Inst.B.E., at the County Technical College, Wednesbury, at 6-30 p.m., on " High Speed Forging Presses."

19th Coventry Section. A lecture will be given by F. E. Rowland, M.I.E.E., on " Infra-Red Heating for Industrial Purposes," at the Coventry Technical College, Room A5, at 6-45 p.m.

19th Western Section. A lecture will be given by F. L. Daniels, M.I.P.E., M.I.Mech.E., F.G.S., on " Geology in Engineering," at the Grand Hotel, Broad St., Bristol, 1, at 6.45 p.m.

20th Manchester Graduate Section. Visit to L.N.E.R. Works, Gorton, Manchester.

20th Shrewsbury Sub-Section. A lecture will be given by N. Matthews, Esq., on " Principles of Foundry Practice," at Shrewsbury Technical College, at 3-00 p.m.

20th Nottingham Section. A lecture will be given by S. C. Roberts, F.C.W.A., M.I.I.A., on " Costing as Applied to Production," at the Demonstration Theatre, The City Gas Showrooms, Lower Parliament St., Nottingham, at 2-30 p.m.

20th Yorkshire Graduate Section. Visit to A. V. Roe and Co., Ltd., Yeadon, Aircraft Manufacturers, at 2-30 p.m.

26th North-Eastern Section. A lecture will be given by T. Swallow, M.I.P.E., on " Production Management Control," at the Neville Hall Mining Institution, Newcastle-on-Tyne, 1, at 6-15 p.m.

26th Lincoln Sub-Section. A Lecture will be given by S. E. Slarke, Esq., on " Sheet Metal Work " at Lincoln Technical College, at 6-30 p.m.

November Meetings.

3rd Yorkshire Graduate Section. A lecture will be given by F. A. Field, Esq., on "The Use and Application of Portable Electric Hand Power Tools," at the Great Northern Hotel, Bradford, at 2-30 p.m.

5th Coventry Graduate Section. "Any Questions Evening," at the Technical College, Coventry, Room A5, at 6-45 p.m.

5th Yorkshire Section. A lecture will be given by T. G. Rose, M.I.P.E., M.I.Mech.E., F.I.I.A., on "How Money moves in Business," at the Lecture Hall, City Museum, Leeds, at 7-00 p.m.

8th Leicester Section. A lecture will be given by E. Hunter, Esq., on "Cast Iron and the Machinist," at the Leicester College of Technology, at 7-00 p.m.

8th South Wales and Monmouthshire Section. A lecture will be given by Dr. W. Wilson on "Electronics in the Service of the Engineer," at the South Wales Institute of Engineers, Park Place, Cardiff, at 6-30 p.m.

13th Manchester Graduate Section. A lecture on "Press Tools" will be given by Messrs. W. A. Bull, Stringleman and Douglass (Mr. Bull will be dealing with the scope of the subject, Mr. Stringleman with design, Mr. Douglass with manufacture) at the College of Technology, Manchester, at 7-15 p.m.

13th North-Eastern Graduate Section. Film Evening at the Newcastle and Gateshead Gas Co's. Demonstration Theatre, St. John St., Newcastle-on-Tyne, at 6-30 p.m.

13th Luton and District Section. A lecture will be given by W. A. Cook, Esq., on "Plastics," at The Small Assembly Room, Town Hall, Luton, at 7-00 p.m.

14th Preston Section. A lecture will be given by V. W. Chandon, Int.A.M.I.P.E., on "Chemical Methods Applied to Production Engineering," at the Canteen of Messrs. Clayton Goodfellow and Co., Ltd., Atlas Iron Works, Blackburn, at 7-15 p.m.

14th London Section. A Lecture will be given by L. E. Earle, B.Sc., A.R.S.M. on "A Brief Study of Soft Soldering (including a Review of some recent Researches)." at the Institution of Mechanical Engineers, Lecture Hall, Storey's Gate, St. James' Park, S.W.1, at 6-30 p.m.

15th Glasgow Section. A lecture will be given by A. L. Hipwell, Esq., on "Negative Rake Turning and Milling," at the Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, C.2, at 7-15 p.m.

November Meetings.—*cont.*

16th Manchester Section. A lecture will be given by W. Puckey, Esq., on "Managerial Aspects of Full Employment in Industry," at the Mechanics Institute, Crewe, at 7-15 p.m. *Provisional.*

16th Western Section. A lecture will be given by R. E. Rowland, M.I.E.E., on "Infra-Red Lamp Heat for Paint Drying" at the Grand Hotel, Broad Street, Bristol, 1, at 6.45 p.m.

16th Coventry Section. A lecture will be given by E. C. Dickinson, M.Met., on "Recent Developments in Foundry Practice," at the Coventry Technical College, Room A5, at 6-45 p.m.

17th Nottingham Section. A lecture will be given by E. W. Hancock, M.B.E., M.I.P.E., on "Time Factor in Industry," at the Demonstration Theatre, The City Gas Showrooms, Lower Parliament St., Nottingham, at 2-30 p.m.

17th Manchester Section. A lecture will be given by W. Puckey, Esq., on "Managerial Aspects of Full Employment in Industry," at the Institute of Industrial Administration, Liverpool University, Brownlow Hill, Liverpool, at 2-30 p.m. *Provisional.*

19th Coventry Graduate Section. A lecture will be given by J. H. Hobbs, Esq., on "Fine Measurement," at the Gas Showrooms, Rugby, at 7-00 p.m.

19th Derby Sub-Section. A lecture will be given by L. S. Delapena, Esq., on "Machine Tools," at the School of Art, Green Lane, Derby, at 6-30 p.m.

19th Halifax Section. A lecture will be given by C. A. Gladman, Esq., on "Engineering Drawings in Relation to Production and Inspection," at the Technical College, Huddersfield, at 7-00 p.m.

21st Manchester Section. A lecture will be given by Dr. D. F. Galloway, B.Sc., Director of Research I.P.E., on "Machine Tool Research and Development," at the College of Technology, Manchester, at 7-15 p.m.

21st Sheffield Section. A lecture will be given by Dr. H. A. Fells, on "Gas Furnaces and Industrial Heating," at the Royal Victoria Hotel, Sheffield, at 6-30 p.m.

21st Birmingham Section. A lecture will be given by Vincent Everard, Esq., on "Industrial Relationship," at the James Watt Memorial Hall, at 7-00 p.m.

23rd Yorkshire Graduate Section. Visit to Dean Smith & Grace, Ltd., Keighley, Lathe Manufacturers, at 2-30 p.m.

November Meetings.—*cont.*

24th Manchester Section. A lecture will be given by A. G. Doughty, Esq., on "Use of Disabled Personnel in Industry," at Liverpool University, Liverpool, at 2-30 p.m.

24th Shrewsbury Sub-Section. A lecture will be given by E. W. Hancock, M.B.E., M.I.P.E., on "Jig and Fixture Design," at Walker Technical College, Oakengates, at 3-00 p.m.

27th North-Eastern Section. A lecture will be given by W. Shield, Esq., on "The Cost Accountant's Point of View in Relation to the Production Engineer," at the Neville Hall Mining Institution, Newcastle-on-Tyne, 1, at 6-15 p.m.

30th Lincoln Sub-Section. Joint meeting with The Engineering Society. T. G. Tanner, B.Sc., will lecture on "High Frequency Induction Heating," at Lincoln Technical College, at 6-30 p.m.

December Meetings.

3rd Coventry Graduate Section. Joint Meeting with the Graduate Section of Inst. of Mechanical Engineers, Inst. of Automobile Engineers and Royal Aeronautical Society. Full details to be announced later.

3rd Yorkshire Section. A lecture will be given by A. McLeod, M.I.P.E., on "The Technical Press as an Aid to the Production Engineer" at the Hotel Metropole, Leeds, at 7-00 p.m.

7th Western Section. Annual Dinner, Grand Hotel, Bristol, 1. Full details to be announced later.

7th Leicester Section. Joint meeting with the Leicester Association of Engineers- R. M. Evans, Esq., will lecture on "Making a Typewriter," illustrated by lantern slides, at the Leicester College of Technology, at 7-00 p.m.

8th Manchester Graduate Section. Visit to Metropolitan-Vickers, Co. Works, Trafford Park, Manchester.

8th North-Eastern Section. Social Evening, Nveille Hall Mining Institution, Newcastle-on-Tyne.

8th North-Eastern Graduate Section. Works Visit to Messrs. Bushing Co., Ltd., Team Valley Trading Estate, Gateshead.

12th Preston Section. A lecture will be given by V. W. Pilkington, Esq., on "Impressions in America," at the Municipal Technical College, Manchester Rd., Bolton, at 7-15 p.m.

12th Wolverhampton Section. A lecture will be given by J. H. Paterson, D.Sc., on "Replacement of Castings by Welded Fabrication," at the Wolverhampton and Staffordshire Technical College, at 6-30 p.m.

December Meetings.—*cont.*

13th Leicester Section. A lecture will be given by F. J. Everest, Esq., on "Developments in Gear Cutting and Finishing Processes," at the Leicester College of Technology, at 7-00 p.m. This lecture will be illustrated by Lantern Slides.

13th South Wales and Monmouthshire Section. A lecture will be given by A. E. Walsh, M.B.E., A.M.I.I.A., on "Personnel Management, Industrial Psychology, their Place in Post-War Industrial Economy," at the South Wales Institute of Engineers, Park Place, Cardiff, at 6-30 p.m.

13th London Section. A lecture will be given by A. Craig McDonald, Esq., on "Some Modern Methods of Heat Treatment," at the Institution of Mechanical Engineers, Lecture Hall, Storey's Gate, St. James' Park, S.W.1., at 6-30 p.m.

15th Yorkshire Graduate Section. A lecture will be given by R. W. Whittle, M.I.P.E., M.I.Loco.E., A.M.I.Mech.E., on "Rehabilitation into Industry" at the Great Northern Hotel, Leeds, at 2-30 p.m.

15th Shrewsbury Sub-Section. A lecture will be given by A. W. Wallbank, Esq., on "Protective Metal Finishes," at Shrewsbury Technical College, at 3-00 p.m.

17th Derby Sub-Section. A lecture will be given by T. B. Maddison, A.M.I.P.E., on "Production Methods in Railway Workshops" at the School of Art, Green Lane, Derby, at 6-30 p.m.

17th Halifax Section. A lecture will be given by Dr. D. F. Galloway, B.Sc., Director of Research, I.P.E., on "Technical Design on Machine Tools," at the Technical College. Halifax, at 7-00 p.m.

19th Sheffield Section. A lecture will be given by W. Neville, Esq., on "Shot Peening," at The Royal Victoria Station Hotel, Sheffield, at 6-30 p.m.

19th Birmingham Section. A lecture will be given by A. J. Nicol, Esq., on "Personnel Management as a Service to Production," at the James Watt Memorial Hall, at 7-00 p.m.

20th Glasgow Section. A lecture will be given by R. B. C. Douglas, M.B.E., on "The Training and Employment of the Disabled," at the Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, C.2, at 7-15 p.m.

21st Lincoln Sub-Section. A lecture on "Manufacture of of Tractors and Harversters," at Lincoln Technical College at 6-30 p.m. Details to follow.

October Committee Meetings.

2nd Education Committee at 10-30 a.m., at the Imperial Hotel, Birmingham.

2nd Membership Committee, at 12-30 p.m., at the Imperial Hotel, Birmingham.

The Technical and Publications Committee meet every Wednesday at Institution Headquarters at 5-30 p.m.

The Finance and General Purposes Committee meet once a month at Institution Headquarters.

The Research Committee meet once a month at Loughborough College, Loughborough, Leics.

NOTE.—*It is not possible to give details of the F. and G.P. and Research Committee meetings in the current issue but it is hoped subsequently to fix a standing date for these.*

Obituary.

It is with deep regret that we record the death of Mr. Bernard Curran, M.I.P.E., Director of Messrs. Edward Curran & Co., Ltd., Cardiff. Mr. Curran was a member of the South Wales and Monmouthshire Section from its inception in 1942, and served on the local Section Committee since November, 1942. He was elected Deputy Chairman of the Committee and filled this office for over 12 months. The Members of the local Committee and local Members have appreciated his work for the Section and have stated that they could ill afford to lose such an enthusiastic member.

REORGANISATION OF HEAD OFFICE.

As members are aware, the head office of the Institution has recently undergone drastic reorganisation, and with a view to avoiding delay in dealing with correspondence, etc., members are asked to assist by bearing the following points prominently in mind.

1. Addressing Correspondence to Head Office.

Members are asked to address their correspondence to the "Secretary" and *not* to individuals personally. The only correspondence which should be addressed personally to the Director-General Secretary is that dealing with matters of policy, complaints, etc., which will receive personal and immediate attention. (A note to this effect appears on all Institution letter heads.)

2. Subject Headings.

It will considerably facilitate the work of the office if members would see that their letters bear subject headings for easy reference. Where more than one subject is dealt with in the same letter each paragraph should bear its own subject heading.

3. Tickets and Programmes for Lectures, Meetings, Works Visits, etc.

Hon. Section Secretaries, when forwarding their requests for the printing of such tickets, are asked to enclose with their covering letter a *pro forma* showing their exact requirements, layout, etc. It will be appreciated that it is very difficult for a member of the staff at this office to interpret the exact requirements of the Section from brief particulars contained in a letter. These requests should reach the office 30 clear days prior to the date of the meeting, etc.

Notice.

Our Accounts Department have received a Postal Order No. R1/57 207283, value 15s. 9d., with the Sheffield postmark—12th July, 1945, without the name of the sender or any further details. This would appear to be a subscription (War Service rate) of one of our members. Would the sender kindly communicate with the Head Office.

Books Received.

Diamond Tools, by Paul Grodzinski, A.M.I.Mech.E. Published by Industrial Diamond Review, London, W.6. Price 20s.

British Plastics Year Book, 1945. Published by Iliffe & Sons, Ltd., London, S.E.1.

A First Guide to Quality Control for Engineers. Published by M.O.S. Dept. for Advisory Service on Statistical Methods.

And also the following publications of the National Foremen's Institute Inc., Deep River, Conn.

Job Safety Training Manual. Brief and Intensive Training Programme for Supervisors, by Kenneth L. Faist and Stanton M. Newkirk.

How to Train Your Assistants. A tested Method for All Foremen, Supervisors and Departmental Heads, by Richard W. Wetherill.

What the Foreman Needs for Success. Tested Methods of Success for Foremen, Supervisors and Department Heads.

Research Department: Production Engineering Abstracts

(*Prepared by the Research Department.*)

NOTE.—*The Addresses of the publications referred to in these Abstracts may be obtained on application to the Research Department, Loughborough College, Loughborough. Readers applying for information regarding any abstract should give full particulars printed at the head of that abstract including the name and date of the periodical.*

HEAT TREATMENT.

Sub-Zero Treatment Improves Tool Life. (*Machinist*, 11*th August*, 1945, *Vol.* 89, *No.* 18, *p.* 597, 3 *figs.*)

Cutting tools and thread dies used by a company making bolts and nuts are cold-treated at a temperature down to 1—120 deg. F. Heat-treating data and production figures are given: the latter show that tool life is often doubled.

Heating Metals and Non-metallic Materials by Electronics. (*Machinery*, 9*th August*, 1945, *Vol.* 67, *No.* 1713, *p.* 141,11 *figs.*)

Metals can be heated by eddy currents induced by electro-magnetic means. A feature of this method is the localization (which can be controlled) of the heat near the outside surfaces of the job. Induction heating can be obtained by four methods, but only the electronic system is considered here. The basic elements are: a transformer, rectifier tubes, oscillator tubes, capacitors, and inductance coils. The distribution of the high-frequency electro-magnetic field is governed by the heater coil design, thus enabling special requirements to be observed. Examples of coils for a variety of purposes are described. Non-conducting materials can be heated by dielectric heating where the workpiece is placed between two or more plates. The alternating electric field is set up by means of a high-frequency vacuum-tube oscillator similar to that used in induction heating. Because the heating effect takes place throughout the material or workpiece, instead of merely close to the surface as in induction heating, this process is suitable for curing impregnated materials, gluing, bonding, and pre-heating plastics. Examples of this system are also described.

BELTS, ROPES.

Belts for Special Jobs, by H. Stuart Jude. (*Power Transmission*, 15*th August*, 1945, *Vol.* 14, *No.* 163, *p.* 679, 6 *figs.*)

The types described include: taper cone belts, V.S.G. belts, belts for oily conditions, cord belts, belts for foodstuffs manufacture, quarter-turn belts and belts for planers and high-speed spindles.

COOLANT, LUBRICANT.

Removal of Swarf from Grinding Coolants. (*The Machinist*, *25th August*, 1945, *Vol.* 89, *No.* 20, *p.* 667, 4 *pp.*)

Metal particles, abrasive and bonding debris should be removed from grinding coolants. A new method uses the ordinary rate of coolant flow to set up rotation in a circular tank sufficient to separate the swarf centrifugally.

The Function of Grinding Fluids. (*Machinery*, *23rd August*, 1945, *Vol.* 67, *No.* 1715, *p.* 219.)

A brief review of grinding fluids.

EMPLOYEES.

An Approach to Joint Consultation, by A. K. Rice. (*The Engineer*, *20th July*, 1945, *Vol. CLXXX*, *No.* 4671, *p.* 44.)

Joint Consultative and Advisory Committees activities can be divided into two main groups: (1) Those activities which are concerned with production in its technical sense. (2) Those activities which are concerned with production as it is affected by the behaviour of employees and management. The principal successes have been in the second category. General rules for success are: (A) Personnel. (1) All those taking part in joint consultation must be sincere in their intention to make it work. (2) All problems must be broken down into their constituent parts. (3) All known facts must be tabled. (4) All motives must be brought into the open. (5) Opinions must be accepted as honest opinions and there must be no fear of "come-back" for their expression. (6) All taking part must have the courage to admit their ignorance and confess their mistakes. (B) Machinery. (1) While actual constitution is unimportant, the joint consultative body must have a definite authority and a specific responsibility for the manner in which it carries out that authority. (2) There must be no artificial limits on the subjects which may be discussed. (3) All those taking part must have an opportunity to study all the facts of the problem under discussion. (4) The joint consultative body must be representative of all those who might be affected by its decisions. (5) The deliberations of the body must be reported promptly to its constituents. (6) Action must follow rapidly on decision.

Training Engineering Employees, by C. G. Chantrill. (*Engineering*, *13th July*, 1945, *Vol.* 160, *No.* 4148, *p.* 24.)

The necessity for the continuous peace-time development of personnel is in danger of being overlooked because of urgent change-over problems. Every individual throughout the industry, irrespective of grade or sphere should be made thoroughly competent by a comprehensive plan for guided progress through recruitment, selection, technical education and functional training. These stages are discussed in turn and schemes suggested. Considerable attention is paid to the lessons of wartime training, the use of psychological selection, and the allocation of responsibility for various stages of training.

Immediate Elements of Reconstruction, by John McHale. (*Mechanical World*, *3rd August*, 1945, *Vol.* 118, *No.* 3057, *p.* 115.)

The author discusses the results of wartime experience in industrial development and personnel management and how they may be applied to early expansion during re-conversion. Particular attention is paid to the probable attitude of returning servicemen, and industrial planning, welfare and location.

FOUNDRY, MOULDING.

Foundry Mould and Core Paints, by W. J. Rees. (*Engineering*, 13*th July*, 1945, *Vol.* 160, *No.* 4148, *p.* 27.)

In steel-foundry operations the risk of silicosis is considerable and investigations for the prevention of the production or inhalation of dust and the possibility of reducing the use of materials containing free silica have been carried out. Results have shown that it is practicable, efficient, and economic to use parting powders containing no free silica and paints prepared from non-siliceous materials. The properties of various types are discussed.

Die-casting Threaded Components. (*Machine Shop Magazine*, *July*, 1945, *Vol.* 6, *No.* 7, *p.* 41, 6 *figs.*)

Cast five at a time, small components that are threaded both internally and externally are produced economically ; power drives are provided to unscrew and re-position thread-producing cores so that the minimum of time is required.

GEARING.

Latitude in the Design of Spiral Gears, by W. A. Tuplin. (*Machinery*, 26*th July*, 1945, *Vol.* 67, *No.* 1711, p. 91.)

The problem of determining the pitch diameters of a pair of spiral gears that are to have specified centre distance, numbers of teeth and normal pitch resolves itself into the determination of the value of the helix angle of engagement. A rigid solution presents practical difficulties and an exact determination of the limits between which the normal pitch of generation must lie is somewhat tedious. Accordingly, rules have been devised to offer some of the latitude that is permissible without the intricacies of calculation necessary to ascertain its full extent, and their use is demonstrated with the aid of worked examples.

Geared-Turbine Locomotive Uses New Engineering Ideas, by J. S. Newton and W. A. Brecht. (*Machinery Lloyd*, 4*th August*, 1945, *Vol. XVII*, *No.* 16, *p.* 49, 6 *figs.*)

This is claimed to be the first commercial application of hardened and ground double helical gearing. The tooth loading and contact hardness (450 Brinell) of the high-speed pinion are more than twice the values commonly used. The first reduction gears are hobbed from material also nearly twice the hardness commonly used. A method of grinding double helical gearing with a flat wheel has been developed.

MACHINE ELEMENTS.

Something New in Remote Control for the Steel Industry, by T. J. Kauffeld. (*Sheet Metal Industries*, *August*, 1945, *Vol.* 22, *No.* 220, *p.* 1356, 9 *figs.*)

A system invented in the U.S.A. for combat equipment has great possibilites for industrial equipment. This system comprises an electro-mechanical device by means of which an operator is able to control a motor-driven mechanism at a remote location, in such a manner that the controlled unit will assume a desired position with extreme accuracy. As an illustration, use of this type of control permits an operator to control the rotation of a shaft connected to an

electric motor and located out of sight and hearing, to any desired angle or angles, within one or many revolutions, with an obtainable accuracy of 1/100 of a degree of rotation maintained throughout any number of operating cycles.

Roller Clutches, by R. Waring-Brown. (*Power Transmission*, 15*th August*, 1945, *Vol.* 14, *No.* 163, *p.* 690, 5 *figs.*)

The design of roller type free wheel mechanisms, as adapted to machinery in general.

MACHINING, MACHINE TOOLS.

The Copy Principle of Machine Operation, Parts 2 and 3, by H. C. Town. (*Machinery*, 26*th July*, 2*nd August*, 1945, *Vol.* 67, *Nos.* 1711, 1712, *pp.* 95, 121, 15 *figs.*)

Part 2. Principles and applications of electrical devices are described. These include the Keller electrical form-control unit ; the four-contact method for form turning ; the electronic method of copying, and copy control by auxiliary finger.

Part 3. The functions of hydraulic devices are similarly described. The methods include the clearing hydraulic duplicator, the Cincinnati valve-deflection system, the G.F. hydro-copying lathe, the combination hydro-electric and pneumatic circuits, portable copying device using a hydraulic motor, and the Escher Wyss hydraulic control for machining ships' propellers. In all cases the underlying principles are fully dealt with.

Don't Set Over the Tailstock for Taper Turning, by Clifford T. Bower. (*Machine Shop Magazine*, *July*, 1945, *Vol.* 6, *No.* 7, *p.* 50, 2 *figs.*)

The author complains that existing arrangements for setting over lathe tailstocks for taper turning are inadequate. They do not permit of instantaneous accurate adjustment for tapered work or for re-aligning for parallel work. He describes a device for giving rapid and accurate adjustment for a back centre.

Controlled Finish on Journals Can be Produced Economically, by H. S. Indge. (*The Machinist*, 28*th July*, 1945, *Vol.* 89, *No.* 16, *p.* 533, 7 *figs.*)

Mechanical lapping with coated abrasive strip is a fast means of refining ground journals to a surface finish of 2-3 micro-inches r.m.s., and do so on a consistent basis. By using strips of this material, correctly proportioned to the work, and properly supported to envelop the work, uniform results are obtained in lapping simple journals or more complicated items such as crankshafts and camshafts. Before abrasive wear can become a factor, the work is finished and a new section of strip is used. Furthermore, the geometry of the workpiece is not altered, because the abrasive strip is backed up by a cushioned support shaped to the work contour, and this support is not subject to wear. Selection of grit and work speed is discussed. The length of reciprocation is usually critical, but the work speed, rate of oscillation, and cycle time are not too critical. Coolant is always used. Examples of work, with machine arrangements and production times are included.

Lapping Operations in the Production of Gears and Worms, by H. J. Wills and H. J. Ingram. (*Machinery*, 16*th August*, 1945, *Vol.* 67, *No.* 1714, *p.* 184.)

Many faults can be corrected by lapping. Methods and suitable compounds for dfferent types of gear are briefly indicated.

Connecting-rod Production for the Napier Sabre Engine. (*Machinery*, *26th July*, 1945, *Vol.* 67, *No.* 1711, *p.* 85, 10 *figs.*)

Methods at an M.A.P. " Shadow " factory.

Machining Cylinder Heads and Sleeve Cranks. (*Machinery*, *2nd August*, 1945, *Vol.* 67, *No.* 1712, *p.* 113, 10 *figs.*)

Napier practice for Sabre engines.

CHIPLESS MACHINING.

Dies Made from Cerrobend. (*Machinery*, *5th July*, 1945, *Vol.* 67, *No.* 1708, *p.* 1, 8 *figs.*)

A method for limited production, using a low melting point alloy, has proved useful in making parts in small quantities. This alloy possesses physical properties that make it suitable for producing hand-forming, hydraulic press, and drawing dies, also power-brake joggle dies. After commenting on the uses of the alloy for the bending of thin rolled tubes and thin materials, its use for dies is outlined. A part can be used as the pattern, or if this is not available, modelling clay, plaster-of-paris, sheet metal, or soft wood can be used, and the alloy can be cast directly against the pattern. The punches and dies are claimed to give remarkable results, even under the severe blows of drop-hammers or the heavy pressures of hydraulic presses.

MATERIALS.

Extruded Metals, by E. J. Cartwright. (*Machine Shop Magazine*, *July*, 1945, *Vol.* 6, *No.* 7, *p.* 34, 7 *figs.*)

The present methods and types of machines, and the applications of extruded products, are discussed. The review is of a general nature and no detailed descriptions or drawings of machines, etc., are given.

MEASUREMENT, INSPECTION.

Laboratory Control in Machine-tool Production. (*Machinery*, 16*th August*, 1945, *Vol.* 67, *No.* 1714, *p.* 169, 8 *figs.*)

Equipment and methods at the works of A. A. Jones and Shipman, Ltd., are described. Following the policy of improving the accuracy of parts produced in the machine shops with a view to decreasing, and in some cases eliminating altogether, the necessity for subsequent fitting, rapid methods of checking are essential, and the gauging equipment must be of the best quality and maintained in first-class condition. As an example of the avoidance of fitting after machining, the table of a face grinder is cited ; it is ground in position on its machine to within a limit of 0.00025-in. for flatness, and is not afterwards submitted to either machining or hand-finishing operations. Accurate grinding spindle and bearings are therefore required. Surface finish of spindles is checked as well as dimensional accuracy. The article also describes the checking of indexing wheels, and twist drill and centre drill points.

Nomogram for Quality. (*Production and Engineering Bulletin*, *July*, 1945, *Vol.* 4, *No.* 31, *p.* 256, 1 *fig.*)

A quick method of estimating the quality of the work produced by a machine has been evolved. Allowance can be made for setting errors and the chart can also be used to answer the question as to what tolerance the machine can hold.

PLASTICS.

The Strength of Internal Threads in Plastic Materials. (*Machinery*, *9th August*, 1945, *Vol.* 67, *No.* 1713, *p.* 163.)

Results are given from German experiments which covered static and fatigue strength of screwed connections of a moulded plastic nut (formaldehyde-base resin) fitted to a steel bolt. The nuts were cut out of standard sheets, previously drilled and threaded, the height of nut being usually three times that of the corresponding bolt diameter. The minimum bolt dimensions to ensure that fracture under tensile load should occur in the bolt before stripping the thread are given for different plastics. The only practical way of achieving high ultimate loads of the bolt and nut construction is to use coarse threads and make up for the reduced core area by employing a higher grade steel for the bolt. Minimum nut dimensions are also given.

Infra-Red Heating, by T. A. Roberts and G. J. Hadderfield. (*Aircraft Production*, *August*, 1945, *Vol. VII*, *No.* 82, *p.* 359, 2 *figs.*)

This process has now been developed for pre-heating moulding powders in the plastics industry, and avoids difficulties incurred in other methods such as ordinary oven or high-frequency heating. With infra-red heating the temperature of the air is ignored, but that of the article to be heated is raised rapidly by bombardment with heat from a relatively high temperature source. From experiments with various types of plastic materials in powder, granule, strip and pellet form, success has been attained in defining the appropriate wavelengths for giving uniform heating throughout the mass of material, thus avoiding pre-curing the outside before the centre reaches the working temperature.

RESEARCH.

National Post-War Research Plans, by R. S. Russell. (*Australasian Engineer* (*Science Sheet*), *7th May*, 1945, *p.* 10, 8 *figs.*)

This review of post-war plans is primarily for Australian engineers, but the careful objective surveys of British and U.S.A. schemes are of general interest.

SHOP ADMINISTRATION AND MANAGEMENT.

The Technique of Production Planning, by D. Tiranti. (*Machine Shop Magazine*, *July*, 1945, *Vol.* 6, *No.* 7, *p.* 45.)

Part I. The author first divides the subject into: (1) Production planning technqiue. (2) Production analysis. (3) Determination of manufacturing quantities. (4) Instructions for: (*a*) Initiation of planning. (*b*) Product analysis. (*c*) Process planning. (*d*) Batching. (*e*) Economic batch size. (*f*) Assembly call-up. (*g*) Unit breakdown. (*h*) Material call-up. (*i*) Part list. Each item is then fully discussed in turn.

Organizing for Production, by D. Tiranti. (*Mechanical World*, *24th August*, 1945, *Vol.* 118, *No.* 3060, *p.* 199, 4 *figs.*)

Initiation, authorization, techniques and different types of production.

SMALL TOOLS.

Rubber Tooling in Naval Gun Production. (*Machinery*, 23*rd August*, 1945, *Vol.* 67, *No.* 1715, *p.* 197, 14 *figs.*)

Rubber is used either for guiding purposes or for expanding abrasive stones radially in the honing of internal surfaces. It is used instead of hard wood for packing bit-tools. The big advantage derived is that this type of packing lasts much longer than hard-wood blocks which become oil-soaked, expand, and must be discarded. Rubber merely utilizes the oil for lubricating and is silent. The construction of these tools is shown.

Methods of Sharpening Peripheral and Formed Profile Milling Cutters, by M. Martellotti. (*The Machinist*, 28*th July*, 1945, *Vol.* 89, *No.* 16, *p.* 550, 10 *figs.*)

Part 10. The author gives practical notes on the use of several types of abrasive wheels, the clearance setting dial, and various methods of grinding clearance. Tables are given which eliminate the need of calculation for different set-ups.

Burnishing Broaches. (*The Engineer*, 20*th July*, 1945, *Vol. CLXXX*, *No.* 4671, *p.* 56.)

Details and dimensioned drawings of burnishing broaches for (railway) bronze bushes.

Selection and Application of Twist Drills. (*The Machinist*, 4*th August*, 1945, *Vol.* 89, *No.* 17, *p.* 569, 55 *figs.*)

After dealing with drill nomenclature, drill standards, and the design of standard and special purpose drills, the article describes how twist drills should be used. Recommendations are made for general drilling technique, drill grinding, and speeds and feeds for commonly used materials.

Alignment Chart for Length of Twist Drill Point, by L. de L. Berg. (*The Machinist*, 25*th August*, 1945, *Vol.* 89, *No.* 20, *p.* 685.)

Chart for finding how far the drill point extends beyond the full-body size.

SURFACE, SURFACE TREATMENT.

The Salt Spray Corrosion Test, by G. T. Dunkley. (*Mechanical World*, 17*th August*, 1945, *Vol.* 118, *No.* 3059, *p.* 179, 2 *figs.*)

Up to the present, the salt spray test has not been regarded as conclusive but this may be due to the lack of standardization. However, of the many tests that have been devised it is the one that continues to receive attention. Some of the main uses of the test are: (1) Testing the porosity of cathodic coatings. (2) Checking the thickness of anodic coatings. (3) Estimating the life of a coating. (4) Testing oxide and phosphate coatings. (5) Examining paint and lacquer films. (6) Determining the tendency of the copper-zinc alloy to dezincification. (7) Examining the behaviour of two metals coupled together. (8) Development of new alloys. (9) Testing of zinc-base diecastings for tendency to inter-crystalline corrosion. Practical points in testing and the advantages and disadvantages of the test are carefully considered in detail. The factors that should be considered for the standardization of the test are: temperature, humidity, particle size and appearance of the fog, salt, solution, air supply, cabinet and specimen racks and nozzles.

The Chemical Control of the Hot-Dip Galvanizing Process, by F. F. Pollak and E. F. Pellowe. (*Sheet Metal Industries, August*, 1945, *Vol.* 22, *No.* 220, *p.* 1349, 5 *figs.*)

Pickling procedure, rinsing and fluxing, drying and galvanizing, evaluation of the quality of the coating, examination of pickle solution, examination of flux solution, examination of etching solution, and the examination of spelter are described, with details of laboratory procedure.

Securing Fine Surfaces, by H. J. Wills. (*Machinery, 9th August*, 1945, *Vol.* 67, *No.* 1713, *p.* 151.)

Operations in the tool room include the lapping of Stellite and cemented carbide tools, and steel gauges. Appropriate compounds and their use are considered.

WELDING.

Resistance Welding, by R. W. Ayers. (*Aircraft Production, August*, 1945, *Vol. VII, No.* 82, *p.* 379, 18 *figs.*)

Part I. Modern developments and applications in up-to-date fabrication methods are described. Materials which can be resistance welded, fundamental factors in spot welding, timers and contactors, and power-operated, multiple-electrode, and portable machines are reviewed.

Thermal and Metallurgical Aspects of the Welding of Hot-dip Galvanized Steel, by E. F. Pellowe and F. F. Pollak. (*Sheet Metal Industries, August*, 1945, *Vol.* 22, *No.* 220, *p.* 1423, 7 *figs.*)

Spot and projection welding only are discussed. A short, sharp heat is advantageous as (*a*) the longer the copper electrodes are in contact with zinc, the greater the attack upon them with subsequent brass formation ; (*b*) with a longer time the quantity of noxious zinc oxide fumes given off is greater, and consequently the health risk of the operator may be involved ; and (*c*) the outside zinc surface would be burned and deeply scarred and consequently extra work would be involved in cleaning up. Further, the squeezed-out zinc covers the weld completely, and gives extra corrosion resistance ; little is lost by volatilizing and not much time is allowed for zinc-iron alloy formation to occur or to diffuse inside the weld and form a brittle weld. The electrodes will meet with a definite attack from the zinc coating, and the authors recommend that a large stock of electrodes be kept cleaned and issued as required. Water-cooled electrodes should have the correct tap size. Etching galvanized work preparatory to painting with phosphate or phosphoric acid preparations leaves an insulating film of phosphate on the work, and causes considerable difficulty in welding. With projection welding the projections should be made before galvanizing.

The Welding of Doxford Engines, by J. L. Botwright. (*The Engineer, 3rd August*, 1945, *Vol. CLXXX, No.* 4673, *p.* 93, 10 *figs.*)

The Flame Cutting of Steel, by Chas. A. E. Wilkins and Wm. J. Currie. (*Australasian Engineer* (*Science Sheet*), *7th May*, 1945, *p.* 21, 5 *figs.*)

The authors demonstrate how precision flame cutting has effected considerable saving in both time and production costs in the engineering industry. They stress the importance of understanding the mechanics of the cutting process,

and of appreciating the metallurgical reactions involved. Flame-cutting has many advantages but one of its greatest is the way it eliminates superfluous machining operations.

WELFARE, SAFETY.

The Safe Installation and Use of Abrasive Wheels, Parts I and II. (*Engineering, 20th, 27th July*, 1945, *Vol.* 160, *Nos.* 4149, 4150, *pp.* 44, 63.)

This article is a detailed review of "The Safe Installation and Use of Abrasive Wheels," published by the I.L.O. The composition and manufacture of abrasive wheels are first described. The principal danger in the use of grinding machinery arises from bursting of the wheel, for which many causes may be responsible. These are discussed in turn. The results of some bursting tests carried out by various workers are reviewed. For ordinary bonded types the report recommends that, for rough or general purpose grinding, peripheral speeds of 4,500 ft. to 5,500 ft. per minute are amply sufficient to achieve efficient working combined with an economic life of wheel, and that 5,500 ft. per minute represents the maximum speed compatible with safety. For precision grinding, peripheral speeds up to 6,000 ft. per minute are safe for periphery wheels and 5,500 ft. per minute for cup or cylinder wheels. Bakelite and resinous bonded wheels are used at speeds up to 9,000 ft. per minute. Elastic bonded wheels for cutting off are considered safe to run at 8,000 ft. per minute. Magnesite and oxychloride bonded wheels should not be used above 4,000 ft. per minute, and even at this speed should be subject to special precautions as regards guards and examination. Grinding operatives should be strongly impressed with the fact that doubling the rotational speed of a wheel increases fourfold its tendency to burst. Choice of the correct wheel for a particular type of work may exert an important influence upon its safe, as well as its economical, use, e.g., a wheel which glazes rapidly may be overheated with consequent risk of fracture. Flaws must be guarded against. Careful visual scrutiny, followed by gentle tapping of the suspended wheel with a light wooden mallet, usually suffices to reveal any flaw. Care in storage is essential to prevent accidental damage. Recommendations are made for storage and mounting in the machine, including keying and gripping. The report emphasizes the need for close supervision of all grinding plant to prevent accidents due to: no guards, jamming work, side-grinding, water absorption, chemical attack, wrong speeds and drive defects. Other aspects discussed are design of guards, sources of accidents apart from bursting, precautions for grinding magnesium alloys, injury due to inhalation and its prevention by dust extraction, and legislation in different countries, with comments thereon.

WORKS AND PLANT.

Engine Washing. (*Aircraft Production, August*, 1945, *Vol. VII, No.* 82, *p.* 361, 3 figs.)

To avoid the contamination of paraffin with cresylic acid, with consequent dangers to operators and heavy consumption of paraffin, a centrifugal cleaning unit has been modified to enable the acid to be neutralized by caustic soda. The caustic soda is immiscible with paraffin and is separated by an additional centrifugal separator.

INDEX TO ADVERTISEMENTS

As a war-time measure the advertisement section of this Journal is now published in two editions, A and B. Advertisers' announcements only appear in one edition each month, advertisements in edition A alternating with those in edition B the following month. This Index gives the page number and edition in which the advertisements appear for the current month.

The fact that goods made of raw materials in short supply owing to war conditions are advertised in "The Journal" should not be taken as an indication that they are necessarily available for export.

THIS IS THE MACHINE FOR THE JOB

The Wickman-Neven BENCH GRINDING & LAPPING MACHINE

SPECIAL FEATURE PUMP, DIAPHRAGM TYPE

This machine is specially designed for the use of Neven Impregnated Diamond Wheels. □ The direction of rotation of the 1 h.p. motorised spindle can be reversed by a switch mounted on the machine enabling right or left hand tools to be lapped with maximum convenience. □ A special feature of the machine is the swivel guard, which can be easily reversed as and when required, enabling one side of the wheel to be completely covered when not in use. □ Protractor scale is provided enabling the table to be adjusted instantaneously from 0-5° negative and 0-15° positive. □ Adjustment of the table is made by a micrometer screw conveniently fitted on the left hand side of the machine.

SPECIFICATION

Wheel supplied (Neven diamond—any grade) ... 6 in. dia. × $1\frac{1}{4}$ in. bore
Size of table ... ... 12 in. × 8 in.

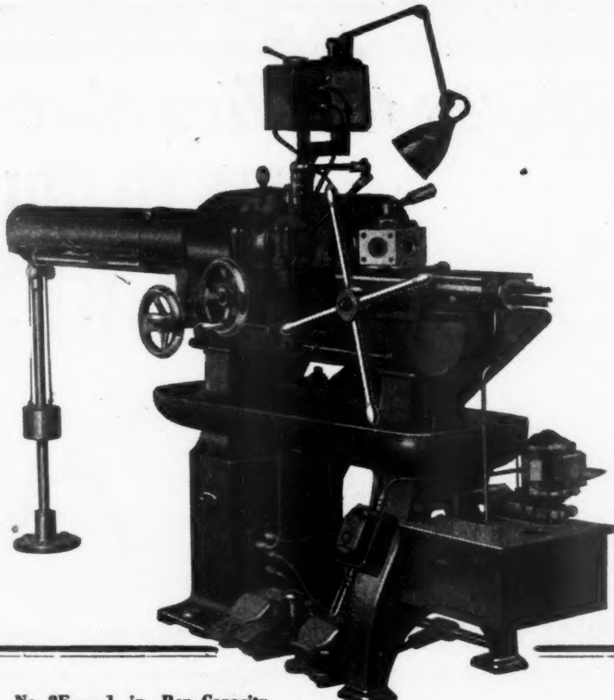
A. C. Wickman LIMITED
• COVENTRY • ENGLAND •

BIRMINGHAM MANCHESTER LEEDS GLASGOW NEWCASTLE

Delivery is subject to priority and purchase certificate issued by the M.T.C.


99·99+%

Robert Sharp & Partners C.54



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